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Williston Reservoir Stream Access Improvements - Assessment Protocol And Mitigation Options

Aquatic Resources Limited Report #444-2
April 2002

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The Peace/Williston Fish & Wildlife Compensation Program is a cooperative venture of BC Hydro and the provincial fish and wildlife management agencies, supported by funding from BC Hydro. The Program was established to enhance and protect fish and wildlife resources affected by the construction of the W.A.C. Bennett and Peace Canyon dams on the Peace River, and the subsequent creation of the Williston and Dinosaur Reservoirs.

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Prepared for:

Peace-Williston Fish and Wildlife Compensation Program
Prince George, BC.

Aquatic Resources Ltd

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1.0 INTRODUCTION

Williston Reservoir was created in 1968 by the construction of the W.A.C. Bennett Dam to generate electricity. The water is released from the reservoir into the Peace River. Normal operation causes an annual water level fluctuation of approximately eleven metres with a record maximum of seventeen meters. Water level is typically lowest at the end of April and highest in September.

Reservoir management, natural inflows, and logging activity results in a continual input of logs and woody debris which are washed onto shore and frequently accumulate at stream mouths as the reservoir level drops. Fish access may be limited by debris accumulations at stream mouths and/or barriers that are created within the draw-down. There are over 240 streams entering the reservoir, many of which have potential fish access problems.

The Peace-Williston Fish and Wildlife Compensation Program (PWFWCP) has identified the need to develop a protocol to assess streams and particularly the draw-down zone of the reservoir for potential barriers that are a result of reservoir management, and to identify options for mitigation. This report, commissioned by the PWFWCP, contains an assessment protocol and results of the assessment on two streams that were visited in the fall of 2001.

The assessment protocol is intended as a tool to define barrier types, severity, potential impact on fish populations, and mitigation options. It will also provide a basis for tracking annual long-term fish access conditions on the reservoir as a whole.

1.1 Study Site

Williston Reservoir is located in north-central British Columbia approximately 200 km north of Prince George. The reservoir is approximately 260 km in length (north to south) and has several arms of significant size including the Peace, Ingenika, Ospika, Nation, and Parsnip arms. The reservoir covers an area of approximately 1770 km^2 at full pool and has a drainage area of 70,000 km^2. The reservoir can be reached by road, however access to the draw-down zone is limited (Figure 1).

The two study streams assessed were accessed by driving approximately 250 km (north) on the Finlay Forest Service Road from Highway 97 just south of Windy Point (Figure 1).

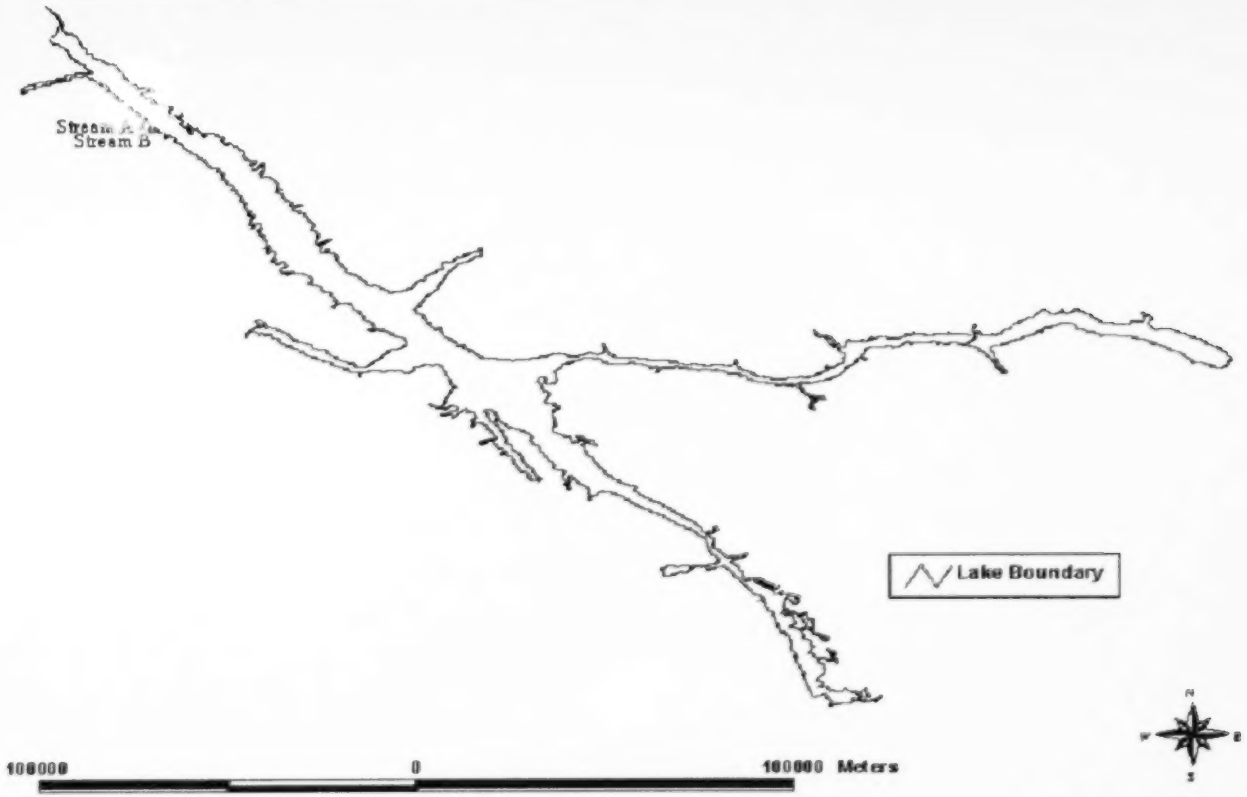

Figure 1:
Map of Williston Reservoir and the location of the two study streams.

2.0 METHODS

The methodology for developing and testing this protocol consisted of the following:

- Review of existing information including reports pertaining to other reservoirs and fish distribution data.
- Helicopter over-flight.
- Analysis of maps and air photos.
- Development of preliminary protocol.
- Field assessment.
- Refinement of protocol.

2.1 Review of Existing Information

We reviewed the following reports:

- Arrow Lake Tributary Debris Survey and Evaluation (ARL, 1999)
- A Fisheries Assessment of Selected Arrow Lakes Tributaries (RL&L 1997)
- A Fisheries Assessment of Selected Arrow Lakes Tributaries (Bayes & Olmsted 1997)
- South Interior Production Debris Management Strategy (1992)
- Seven Mile Reservoir Tributary Fish Access (1998)

These reports provided limited information for the development of this protocol.

Brian Blackman (PWFWCP) provided details regarding reservoir management, air photos, maps, and results of previous examinations of potential stream blockages.

Additional information specific to the streams proposed for field inspection was gathered from the FISS and FishWizard databases.

2.2 Helicopter Over-Flight

On September 11, 2001, representatives from PWFWCP and Aquatic Resources Limited flew the entire perimeter of Williston Reservoir including the major arms (reaches) to identify streams with possible blockages at the mouth. The reservoir was at full pool during the over flight.

Extent and nature of debris accumulation was noted, exact location was recorded with the onboard GPS unit (latitude and longitude) and pictures were taken. Streams with natural barriers (gradient or falls) at or near the mouth were

eliminated from further consideration regardless of debris accumulation status at the mouth. Streams previously identified to have potential blockages at the mouth were also photographed from the air regardless of current potential blockage status.

This information was used to identify two study streams to be assessed with the protocol.

2.3 Analysis of Maps and Air Photos

Air photos and 1:20,000 maps of the area were reviewed to obtain fish and fish habitat information, access, and general site characteristics.

Gradient, cover, potential habitat length, and potential barriers were recorded from maps and air photos. Size, shape, and orientation of stream mouth deltas were also noted.

2.4 Development of Preliminary Protocol

A preliminary protocol was developed using all information gathered to that point. Other assessment standards such as RIC 1:20,000, and WRP Level 1 Assessment (FHAP) and information from reports on Arrow and Seven Mile reservoirs were incorporated where possible. The focus of the protocol was to arrive at a method of assessment that would identify and evaluate fish access problems in terms of severity, potential impact on fish populations, and potential mitigation options.

2.5 Field Assessment

In October 2001 an assessment was made of each of the two test streams. Sites were accessed by four-wheel drive truck. Habitat data was collected on a standard site card (RIC 1998), assessments of habitat quality were also made. Fish sampling was not conducted.

Assessment of the stream within the draw-down zone was not possible due to high reservoir water level at the time of the survey.

Quality and quantity surveys of available habitat upstream from the mouth were conducted to determine a general sense of fish production capability. The assessment was extended 100 meters upstream of culvert barriers discovered in the field.

An assessment was made of the potential barrier at the mouth of the two study streams using the preliminary protocol. Size of debris pile blockage, location, and size of material in the debris jam were recorded. Potential mitigation techniques were discussed in the field. An example of the field assessment data form is provided in Appendix I.

2.6 Refinement of the Protocol

Data collected in the field and subsequent consultation with Brian Blackman and Bob Westcott was used to refine the preliminary protocol.

3.0 PROTOCOL

This protocol is a stepwise approach to assessing reservoir tributaries for fish barriers within the draw-down zone. Once an overview assessment has identified streams with potential barriers, information for three basic elements of a streams is collected; habitat availability, habitat capability, and type of barrier. At each of the three steps data is collected and given a numerical score weighted by importance to fish productivity. These scores are then used to rank a stream as high, moderate or low priority for continued assessment. This process eliminates wasting resources on streams where mitigation would not result in enhancement of fish productivity in a watershed, while extending little risk of accidentally missing opportunities in streams with high fisheries value.

Scores for all parameters and priority rating at each step are recorded on a spreadsheet in order to facilitate tracking and to provide an overview priority ranking. Mitigation options are also discussed but it should be noted that each fish access barrier mitigation scenario will be somewhat unique.

This protocol is the first phase of addressing the long-term management of fish and fish habitat in reservoirs. Recommendations for monitoring frequency are presented for each priority rank in this protocol, however, these recommendations will need to be refined as new information becomes available, particularly regarding the nature and extent of barriers, and frequency of barrier formation.

Step One – Overview Assessment. An initial overview assessment should be conducted for all tributaries to the reservoir. All available information should be compiled in order to determine, if possible, a priority rating for each stream. Available information may identify streams that are at risk of having a barrier, or that are likely to have a barrier in the future. Particularly any information of historic or pre-reservoir fish distribution should be collected. All streams can then be prioritized for further assessment according to their available habitat and fish species assemblage. Information gathered during this exercise will also form

the basis for developing an assessment strategy in terms of annual and long-term survey requirements to ensure continued fish access to streams.

Step Two – Blockage Status. The nature, extent and timing of any barriers are recorded. Detailed diagrams are made to assist in any future mitigation planning.

Step Three – Field Assessment. Streams that were identified to have either a High or Moderate Priority rating from Step One are assessed in the field to determine fish production capability as needed.

Step Four –Mitigation and Prevention. Mitigation and prevention measures are determined for streams with High or Moderate Priority rating.

3.1 Step One: - Overview Assessment

An overview assessment will be conducted for the whole reservoir. This higher level planning will assist in allocating resources for the whole watershed where the most benefit would likely be realized. However, the protocol has been developed so that it may also be applied on an individual stream basis.

Streams that have been identified to have a potential barrier through the overview assessment are prioritized according to available or potential habitat and fish species assemblage. FISS and FishWizard databases should be consulted. Federal and provincial fisheries officials must also be contacted to determine if other fish distribution data is available. Local residents, angling clubs, and First Nations should also be contacted for additional information. Streams known to support blue or red listed species will automatically be listed as high priority for mitigation measures. If fish presence is unknown fish presence should be assumed until habitat assessment indicates otherwise.

The information gathered in this step is to be entered into the Overview Assessment and Prioritization Matrix (Matrix 1) to calculate the priority rating.

Decision Flow Chart

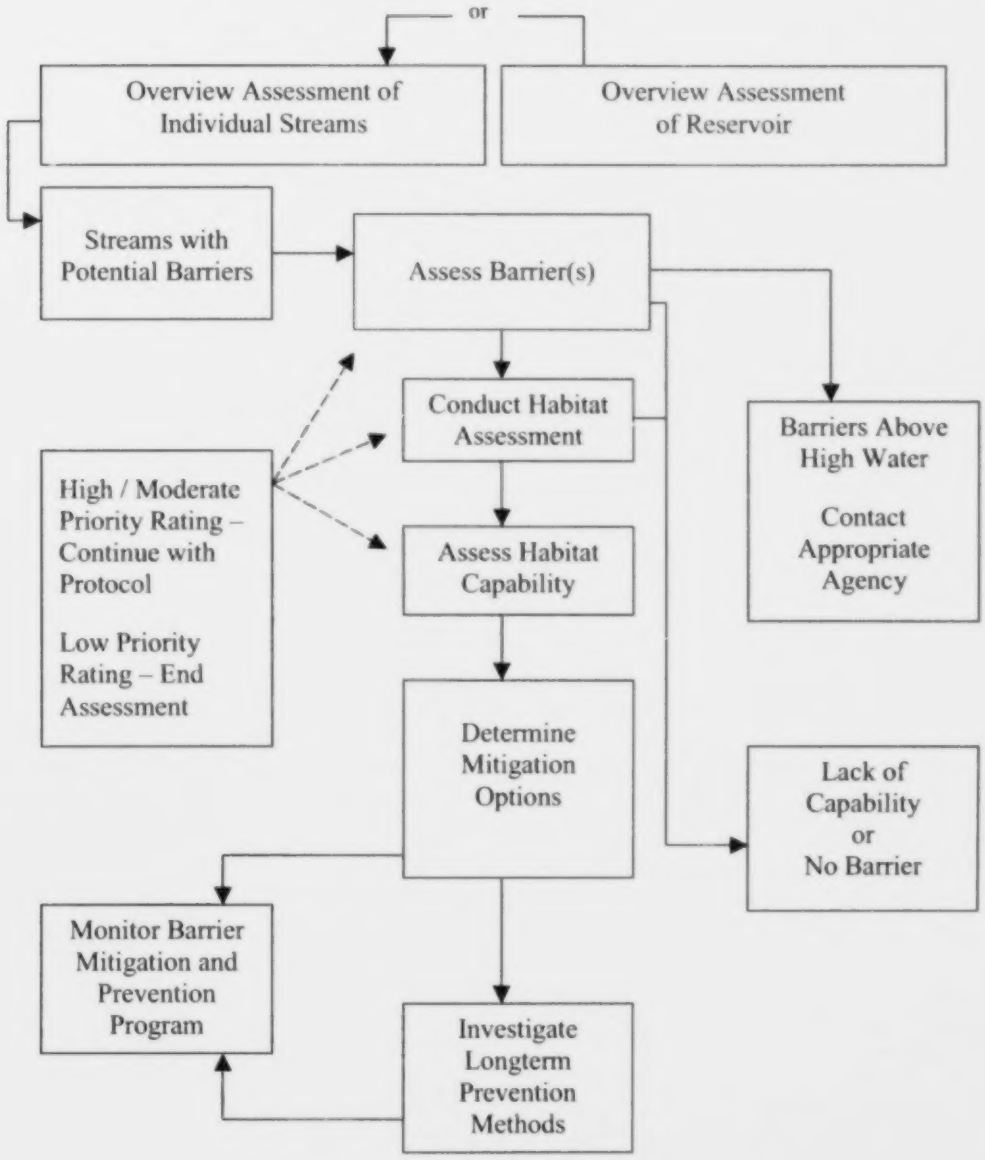
or
Overview Assessment of Individual Streams
Overview Assessment of Reservoir
Streams with Potential Barriers
Assess Barrier(s)
Conduct Habitat Assessment
Barriers Above High Water
Contact Appropriate Agency
High / Moderate Priority Rating – Continue with Protocol
Low Priority Rating – End Assessment
Assess Habitat Capability
Determine Mitigation Options
Lack of Capability or No Barrier
Monitor Barrier Mitigation and Prevention Program
Investigate Longterm Prevention Methods

Figure 2:
Decision Flow Chart

3.1.1 Air Photo and Map Interpretation

The first part of Step One is to identify the amount of stream length (m) available to fish (habitat quantity), starting from the mouth of the stream and including all accessible tributaries. Barriers, such as gradient, falls and manmade barriers (culverts) should be identified and considered when calculating available stream length. If it is unclear if a natural or anthropogenic feature is a barrier it should be assumed that it is not a barrier in order to avoid unknowingly discounting valuable habitat which may be available. Similarly streams suspected to have seasonal discharge should not be discounted.

Review all available FRBC and other reports and maps, air photos to determine this information.

Table 1:
Habitat length summary table.

	Draw-down Zone	Mainstem	Tributaries	Total
Total Length (m):				
Barrier Location				
Barrier Elevation				
Available Length (m):				

List any barriers that were identified in the air photos even if they are not necessarily associated with reservoir management in order to develop a greater understanding of factors affecting potential fish production.

3.1.2 Prioritization Matrix

Information gathered in Step One is entered into Matrix 1 (habitat length, fish presence). All streams for which fish presence is unknown should be treated as fish bearing until shown otherwise. Similarly where fish presence is unknown presence of species of special concern should be assumed until overview or habitat assessments suggest otherwise.

Matrix 1:
Pre-field assessment and prioritization matrix.

Habitat above High Water Mark	5 pts	10 pts	20 pts	Total
Length of Available Habitat (m)	< 200 m	200-1000 m	> 1000 m	
Species Present (can have more than one category)	N/A	N/A	Blue/Red Listed species	Default High Priority
Matrix Score				

Matrix Score:	Priority for Field Assessment (Step Two):
20	High
10	Moderate
5	Low
Blue/Red Listed Species	High

Rationale for Matrix Categories

Habitat Length: The three length categories were chosen with consideration to fish production potential. Unless the species or habitat in question was critically imperiled, mitigation for less than two hundred meters of habitat is not likely warranted.

Species: Presence of provincial Conservation Data Centre (CDC) Blue or Red listed species automatically defaults to high priority for assessing potential barriers and developing mitigation options.

3.2 Step Two: Barrier Assessment

3.2.1 Barrier Types

Best mitigation options will be dictated by the nature, extent, and location of barriers. Detailed sketches and measurements of barriers should be made in order to facilitate development of mitigation plans. These records will also be used to track longevity and frequency of occurrence which in-turn will influence the amount of effort that is warranted in preventing blockages from reoccurring. Barrier types may include one or a combination of the following.

- large logs forming a log jam

- small woody debris forming a log jam
- gradient barrier (falls) in the draw-down zone
- velocity barrier (long glides) in the draw-down zone
- dewatering in the draw-down zone
- channel is obscured, water fanning over the surface

Examine the entire length of the stream channel between the high water mark and low water mark. Draw a longitudinal stream profile to scale. Indicate upper and lower elevations, gradient, and all significant features.

Record substrate type, erodibility, and try to determine if the thalweg is well established or subject to annual changes.

Describe and measure all barriers. Make notes on potential mitigation options and determine if mitigation is possible.

3.2.2 Barrier Severity

All barriers within the draw-down zone should be described and assessed. The location or elevation of the barrier within the draw-down zone will determine the level of impact it has on fish populations and options for mitigation or prevention.

When assessing the importance of a barrier to fish migration, determine if the barrier falls within one of the following categories in Matrix 2. These categories reflect the level of impact a barrier will have in terms of number of species affected, extent of blockage, and timing with respect to reservoir water levels.

Matrix 2:
Barrier ranking matrix.

Score	Barrier Description
30	There is complete blockage at the mouth of the stream or in the draw-down zone that is or would be a complete blockage at all water levels or during all spawning periods.
20	There is a complete blockage in the draw-down zone or at the mouth of the stream that is or would be a complete blockage during some spawning periods only.
10	There is a partial blockage in the draw-down zone or at the mouth of the stream that is or would be only a partial blockage at any time of year. Or there is a blockage in the draw-down zone that is or would be a blockage for some species at some times of the year.
NA	There is no blockage at the mouth of the stream or in the draw-down zone and there would not be a blockage at any time of year.
30	Regardless of severity of barrier streams containing Blue or red listed species present/ or unknown presence should be given high priority for mitigation.

When inspecting the draw-down zone and a barrier make sure to consider the potential for increasing severity over time if no mitigation is carried out. Also consider the potential for barrier re-occurrence if prevention methods are not implemented. These two issues must be considered when prescribing mitigation and monitoring programs.

- The categories in Matrix 2 are necessarily broad and in some cases may not adequately reflect the nature and severity of a barrier or potential mitigation techniques.

The following should also be considered:

- is debris originating from bank erosion, log booms, or the stream itself
- is the blockage only debris related
- is blockage debris and substrate related
- is the barrier only substrate related
- is the barrier gradient/substrate related
- is the barrier gradient related only
- is the channel within the draw-down zone stable

Additionally, when developing mitigation plans also consider that debris has a greater tendency to accumulate in shallow areas with low gradient and also in protected bays.

Relatively small accumulations of smaller sized pieces (<3.0 m long or 0.20 m diameter) can block a stream. This is because this size of debris fits together tightly within the stream channel leaving no spaces for fish to move through. These small debris jams can also become deeply imbedded in sand making removal difficult. Small debris can trap stream substrate materials creating a sediment wedge that can completely block a channel and prevent fish passage.

Woody debris blockages may include floating and water logged pieces. Assessments conducted at high water may not reveal a potential blockage if much of the debris is waterlogged and below the water surface.

3.2.3 Assessment Frequency

Each site will have characteristics that may make it more prone to barrier development. Record all observations regarding potential of blockage formation and possible rate of blockage development.

The level of assessment frequency warranted will depend on likelihood of barrier development and habitat availability and will as more experience is gained over time.

Field inspection should be conducted on all potentially fish bearing tributaries every three years. Results of these assessments will provide guidance regarding potential for barrier formation and consequently required frequency of surveying. Tributaries with significant fish value and high risk of barrier formation should be surveyed annually until prevention techniques have been implemented.

3.3 Step Three: Field Assessment

Streams that were identified to have potential barriers and a High or Moderate Priority rating from Step One and Two are to be assessed in the field to determine actual habitat capability (habitat quality), fish species assemblage and habitat quality.

In context of long range planning a monitoring schedule should be established based on results and observations made during the initial site survey. Each site should be examined for potential of blockage formation and possible rate of blockage development. Record these on the field form.

3.3.1 Assessment Timing

Annual fluctuation patterns in reservoirs affect the nature and extent of potential barriers to fish migration into streams. Permanent barriers to all fish species may exist at any elevation within the draw-down zone. Barriers at the mouth of streams may be visible at all times but others will not be discovered unless water levels are low. Barriers only slightly lower than the high water mark may not be visible at high water but may be as limiting to fish migration during critical times (spawning) as barriers at or above the high water mark.

In order to identify all barriers above and below the high water mark, assessments should be conducted at low water levels, preferably in the spring or early summer. Elevation of barriers in the draw-down zone needs to be recorded as it has implications for reservoir management and/or potential of barrier to be limiting to fish.

3.3.2 Habitat Capability

Uncertainties in the presence or nature of fish habitat availability that were identified in Step One should be visited in the field. New information gathered may require re-calculation of the priority ranking in Step One. For instance, a road crossing culvert barrier near the mouth which is discovered during a habitat capability assessment may reduce availability of habitat and result in a lower priority rating. Although culverts are not necessarily a direct reservoir management issue, until the culvert barrier is addressed, mitigation of blockages at the mouth or in the draw-down zone may not be justified.

Re-Calculated as High Priority: Continue.

Re-Calculated as Moderate Priority: Continue.

Re-Calculated as Low Priority: If the barrier is anthropogenic (culvert, dam etc.), removing the barrier should be considered and the appropriate agency should be contacted. If the barrier is natural (gradient, falls) do not continue with the protocol, mitigation is not justified.

3.3.3 Habitat Capability Matrices

Habitat data should be collected as per RIC standards (RIC 1998). Spawning habitat assessment is subjective and should be done by an experienced fish biologist. Habitat quality data is entered into Matrix 3.

Matrix 3:

Habitat capability matrix.

Flow	**0 pts**	**N/A**	**20 pts**	**40 pts**	**Total**
Flow	No Flow	-	Intermittent	Perennial	
Survey timing should be scheduled to detect low flow in late summer. If stream is suspected or known to be intermittent and total habitat length is low to moderate (Step 1) then consider terminating assessment unless data indicates presence of vulnerable species.					
Gradient	**0 pts**	**0 pts**	**10 pts**	**20 pts**	**Total**
Gradient	>41	25-40	16-24	0-15	
Cover	**0 pts**	**5 pts**	**10 pts**	**20 pts**	**Total**
LWD, U/C Bank and/or Boulder Cover	None	Trace	Subdominant	Dominant	
Vegetation Cover	None	Trace	Subdominant or Dominant	-	
SWD Cover	None	Trace	Subdominant or Dominant	-	
Spawning	**0 pts**	**10 pts**	**20 pts**	**40 pts**	**Total**
Spawning Habitat Quality	None	Poor	Moderate	Good-Excellent	
Species	**Blue or Red Listed Species Present or suspeted**				**Default High Priority**
Matrix Score	Add matrix rows for total score				

Matrix Score	Priority Rating
≥60	High
40-50	Moderate
≤30	Low
Blue/Red Listed Species	High

Rationale for Matrix Categories:

Flow: Rainbow trout and coarse fish may utilize streams with intermittent or seasonal flows. These streams likely have limited value for fall spawners unless fall rains are substantial.

Gradient: A gradient greater than 25 degrees is considered a gradient barrier for most species but may still provide habitat for rearing bull trout. Bull trout may

rear in streams with 25-40 degrees. A high gradient stream that is not suspected of supporting bull trout will receive a zero score for this criteria.

LWD/Undercut Banks/Boulder Cover: Large woody debris (LWD), undercut banks and boulders provide excellent habitat for rearing fish.

Vegetation Cover: Provides excellent rearing and spawning habitat for coarse species that are a food source for some sport fish, and provides good rearing habitat for some sport fish species.

SWD Cover: Small woody debris (SWD) is good cover for rearing fish.

Spawning Habitat: Subjective measure. Quality and quantity of stream bed substrate that is used for spawning by fish. This habitat feature should be given the greatest weight.

Species: Streams with blue and red listed species automatically default to high priority barrier and mitigation assessments, habitat capability rating serves only as supplementary information.

3.4 Mitigation

3.4.1 Mitigation Prioritization Matrix

Use this matrix to determine which barriers warrant mitigation and/or prevention measures.

Matrix 4:
Mitigation prioritization matrix.

	Blue or Red Listed Species 60	Habitat Capability ≥60	Habitat Capability 40-50	Habitat Capability ≤30
Barrier Score 30	High	High	High	Low
Barrier Score 20	High	High	Moderate	Low
Barrier Score 10	High	Moderate	Low	Low
Barrier Score 0	N/A	N/A	N/A	N/A

Matrix Score and Priority:

High Priority: A complete blockage at the mouth or in the draw-down zone is preventing all species from accessing a stream with high to moderate habitat capability. Mitigation and prevention is required.

Moderate Priority: A complete/temporary or partial/permanent blockage at the mouth or in the draw-down zone is preventing all or most species from accessing a stream with moderate or high capability habitat. Mitigation is recommended.

Low Priority: A partial or temporary blockage in the draw-down zone may occasionally prevent migration of some species into the creek. Mitigation is optional.

Blue/Red Listed Species: Default to High priority regardless of habitat capability. If barrier is present, should proceed with development of mitigation plans regardless of severity of barrier.

N/A: There is no blockage present at the mouth of the stream.

4.0 MITIGATION OPTIONS

Mitigation technique is dependent on several factors and experience and professional judgement must be extended in every case.

There are several mitigation techniques that can be used depending on timing, water level, nature of blockage, and access for equipment. Availability of specialized equipment is also a consideration. A variety of techniques may need to be employed at one site. Cost and risk of re-occurrence are also important.

The field survey conducted for this study was completed during high reservoir water level. As a consequence, it was not possible to investigate potential barriers in the draw-down zone nor develop potential mitigation techniques. Therefor, this protocol is based on data from debris barriers at the high water mark only. Additional considerations may need to be added to accommodate fish access issues from below the high water mark.

Table 2:
Mitigation options

Timing	Method	Disposal	Machinery
Full Pool	pile above water line	burn	chainsaw
	pile above water line	leave on site	chainsaw
	remove debris with net/hooks	pile above HWM	tug/barge excavator with thumb
	debris through chipper	load on barge	tug/barge excavator with thumb, chipper
Low Pool	pile by hand above HWM	burn	chainsaw
	pile by hand above water line	burn	chainsaw
	use machine pile within draw-down zone	burn	excvator with thumb, may require tug and barge to transport in inaccessible areas
	debris through chipper	disperse on site above HWM	tug/barge excavator with thumb, chipper
	debris through chipper	load on barge	tug/barge excavator with thumb, chipper

Barriers within the draw-down zone may include water flow issues not associated with debris such as dewatering or fanning over the surface without a distinct channel. These barriers may be permanent, (bedrock or coarse substrate) or temporary (sand and gravel). Different mitigation techniques will apply.

Woody debris can be viewed as either 'fixed' or 'transient'.

Fixed debris tends to be found at or above the highwater mark. It is suspected that winter storm activity in conjunction with high reservoir levels found at that time of year tends to accumulate debris in these locations. Other forms of fixed debris are wood that has become waterlogged, or wood that has become buried by bedload movement at stream mouths. Fisheries values for this waterlogged debris should be considered before any effort to remove it are undertaken.

Transient debris is typically newly recruited debris, which floats around the reservoir and has the highest potential to create stream access problems for fish. Transient debris can also cause navigational problems for recreational and commercial boat traffic.

Long-term monitoring of transient debris often shows trends as to areas susceptible to accumulation. This type of monitoring can be achieved by mapping out areas of debris accumulation in conjunction with surveys of stream channel access. Debris accumulations can then be analysed for trends over

subsequent years. This has the benefit of helping to identify streams at risk for access problems associated with debris.

4.1 Piling and burning

Typically wood is piled for burning when the reservoir is at low pool. This facilitates access for equipment and reduces the risk of sedimentation in the reservoir since work can be conducted on dry ground. Long-term observations in other reservoirs suggests debris tends to accumulate on low gradient shoreline areas (D. Gebhart, pers. comm.). These areas can be determined during overflights and long-term mapping of debris movement. Areas of high gradient or vertical shoreline have low potential for debris accumulation.

Piling of debris is most efficiently accomplished by using an excavator equipped with a thumb. This type of equipment can easily travel over most types of terrain and is easily transported by barge to locations that are inaccessible by road. The largest variable in cost for this technique is for transportation of equipment.

4.2 Booming and burning

When transient floating debris tends to accumulate in a particular area it can be boomed up during high to moderate reservoir elevations and transported to a low gradient embayment area. During reservoir draw-down the debris will become dewatered and can be sorted. Removal of commercially valuable debris from non valuable debris can help offset the cost of this operation. Non valuable debris can then be piled and burned. This technique is being used in other reservoirs, such as Stave Lake, B.C.

4.3 Chipping

Chipping of debris is currently financially non-viable due to low pulp prices. It may become viable in the future and may be a better alternative to burning.

4.4 Other considerations

Prior to conducting any of the above debris removal techniques, appropriate permitting will need to be obtained. Considerations for access to debris should include ensuring equipment does not operate in, or cross, stream channels or fisheries sensitive areas. If in stream work is necessary permits under federal DFO harmful alteration to fish habitat will be required.

5.0 PREVENTION

Methods of preventing blockages over the long-term may also be feasible in some situations. This study occurred during high water levels and so it was not possible

to determine prevention methods. Prevention methods should be investigated during reservoir draw-down. In some cases prevention at a site specific level may not be feasible.

A variety of prevention methods are listed in Table 3. When conducting a site assessment possible prevention methods should be considered including utilizing a combination of methods. For instance log piles across a bay combined with a log-boom between piles may provide better results than either log piles or a log boom alone.

At each site the source of debris should be determined. In some cases debris may be originating from localized bank erosion. This situation can be dealt with in a much different manner than if debris is either being brought in from a river or from logging activity.

Table 3:
List of possible prevention techniques for stopping blockages from forming.

Method	Materials	Site Considerations	Other Considerations
Log Boom	large logs, cable anchors across mouth	• will not prevent small debris or any debris in windy/high wave • could block entry to stream mouth - pose safety hazard for boaters	only suitable for streams with long well protected bays
Steel Piles	steel piles 10-20 m long across mouth	• appropriate substrate required, will not prevent small debris, could block entry to stream mouth - pose safety hazard for boaters	must withstand storms and pressure from large debris accumulation most suitable for well protected bays.
Wood Piles	wood piles 10-20 m long across mouth	• appropriate substrate required, will not prevent small debris, could block entry to stream mouth pose safety hazard for boaters	must withstand storms and pressure from large debris accumulation most suitable for well protected bays.
Culvert/ Artificial Channel	metal or wood culvert	debris removal not necessary as channel will be accessible underneath debris	will require engineered substrate, must extend past debris jam, fish access impeded at full pool
Log Pile Lined Channel	wood piles along channel	suitable substrate for piles side by side for length of channel	cross members for strength, accumulation within the channel

6.0 CONCLUSION

The protocol developed in this report can be used to assess blockages at tributary stream mouths of Williston Lake. The working examples show that the protocol successfully prioritizes which streams require mitigation and prevention measures, and provides general options for mitigation and prevention. The protocol does not calculate costs nor provide detailed procedures for undergoing mitigation and prevention measures. Costs and mitigation procedures need to be determined on a stream-by-stream basis, and may require consultation with engineers, foresters, biologists and representatives of the PWFWCP.

Our survey was conducted at high reservoir water level. A subsequent survey should be conducted a low water level to further investigate conditions within the draw-down zone and those findings incorporated into the existing protocol.

7.0 REFERENCES

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Working Examples

Below are the protocol outputs using the data collected during the field assessment conducted in November 2001 on the two study sites selected to test the protocol. Checkmarks (√) indicate items that were selected in the matrices, tables and decision keys. Crosses (X) indicate choices that were not selected in the Decision Keys.

Stream A

Below is the Protocol output for Stream A (Site 12 - Figure 1).

Step One

1) Possible Barrier List: Two culvert crossings on mainstem.

Table 1:
Air photo summary table.

	Mainstem	Tributaries	Total
Total Length (m):	2000	-	2000
Available Length (m):	2000	-	2000

2) Fish species assemblage information is unavailable.

3) In Matrix 1, length of habitat is > 1000 m, therefor the score is 20 pts. Presence of blue or red listed species is not known or suspected.

Matrix 1:
Pre-field assessment and prioritization matrix.

	5 pts	10 pts	20 pts	Total
Length of Available Habitat (m)	< 200 m	200-1000 m	> 1000 m √	20
Species Present (can have more than one category)			Blue or Red Listed Species	NO
Matrix Score				20

Matrix Score:	Priority for Field Assessment (Step Two):	
20	High	√
10	Moderate	
5	Low	

Step Two

Matrix 2

Blockage Asessment

Score	Barrier Description
30	There is complete blockage at the mouth of the stream or in the draw-down zone that is or would be a complete blockage at all water levels or during all spawning periods.
20	There is a complete blockage in the draw-down zone or at the mouth of the stream that is or would be a complete blockage during some spawning periods only.
10	There is a partial blockage in the draw-down zone or at the mouth of the stream that is or would be only a partial blockage at any time of year. Or there is a blockage in the draw-down zone that is or would be a blockage for some species at some times of the year.
NA √	There is no blockage at the mouth of the stream or in the draw-down zone and there would not be a blockage at any time of year.
30	Blue or Red Listed Species Present

No Blockage Present – Habitat Assessment not Required.

Step Three (Optional since no barrier present)

Matrix 3:
Habitat Capability Matrix.

Flow	**0 pts**	**N/A**	**20 pts**	**40 pts**	**Total**
Flow	No Flow	-	Intermittent	Perennial √	40
Survey timing should be scheduled to detect low flow in late summer. If stream is suspected or known to be intermittent and total habitat length is low to moderate (Step 1) then consider terminating assessment unless data indicates presence of vulnerable species.					
Gradient	**0 pts**	**0 pts**	**10 pts**	**20 pts**	**Total**
Gradient	>41	25-40	16-24	0-15 √	20
Cover	**0 pts**	**5 pts**	**10 pts**	**20 pts**	**Total**
LWD, U/C Bank and/or Boulder Cover	None	Trace	Subdominant	Dominant √	20
Vegetation Cover	None	Trace √	Subdominant or Dominant	-	5
SWD Cover	None	Trace	Subdominant or Dominant √	-	10
Spawning	**0 pts**	**10 pts**	**20 pts**	**40 pts**	**Total**
Spawning Habitat Quality	None	Poor	Moderate	Good-Excellent √	40
Species	**Blue or Red Listed Species Present**				**Default High Priority**
Matrix Score	Add matrix rows for total score				135

Matrix Score	Priority Rating	
≥60	High	√
40-50	Moderate	
≤30	Low	
Blue/Red Listed Species	High	

1) Culvert crossing located approximately 100 m from the stream mouth is a barrier. Re-calculate Matrix 1. New Priority rating is Moderate. Make note to inform appropriate agency about culvert fish barrier.

2) No fish sampling conducted.

3) Data used in Matrix 3 comes from Site Cards filled out during the field assessment. The gradient was 3.0 (20 pts), LWD was the dominant cover item (20 pts), there was only trace amounts of vegetative cover (5 pts), SWD was a subdominant cover (10 pts), and overall spawning habitat was moderate (10 pts). Overall matrix score is 135 pts or High Habitat Capability.

Step Four

Matrix 4:
Mitigation Prioritization Matrix.

	Blue or Red Listed Species 60	Habitat Capability ≥60	Habitat Capability 40-50	Habitat Capability ≤30
Barrier Rank 30	High	High	High	Low √
Barrier Rank 20	High	High	Moderate	Low
Barrier Rank 10	High	Moderate	Low	Low
Barrier Rank 0	N/A	N/A	N/A	N/A

1) No blockage at the mouth at any time of the year. No Score for blockage (N/A).

2) A High Priority rating for Habitat Capability and a score of N/A for blockage together in Matrix 2 results in an overall N/A Mitigation and Prevention Priority rating. This stream is to be re-assessed during low water level to identify any potential barriers in the draw-down zone.

Stream B

Below is the Protocol output for Stream B (Site 13 - Figure 1).

Step One

1) Possible Barrier List: Two culvert crossings on mainstem.

Table 1:
Air photo summary table.

	Mainstem	Tributaries	Total
Total Length (m):	2000	1000	3000
Available Length (m):	2000	1000	3000

2) Fish species assemblage information is unavailable.

3) In Matrix 1, length of habitat is > 1000 m, therefor the score is 20 pts, and no fish information is available, so the score is also 20 pts. The overall matrix score is 40 pts or High Priority for Field Assessment (Step Two).

Matrix 1:
Pre-field assessment and prioritization matrix.

	5 pts	10 pts	20 pts	Total
Length of Available Habitat (m)	< 200 m	200-1000 m	> 1000 m √	20
Species Present (can have more than one category)			Blue or Red Listed Species	NO
Matrix Score				20

Matrix Score:	Priority for Field Assessment (Step Two):	
20	High	√
10	Moderate	
5	Low	

Step Two

Matrix 2
Blockage Assessment

Score	Barrier Description
30	There is complete blockage at the mouth of the stream or in the draw-down zone that is or would be a complete blockage at all water levels or during all spawning periods.
20	There is a complete blockage in the draw-down zone or at the mouth of the stream that is or would be a complete blockage during some spawning periods only.
10	There is a partial blockage in the draw-down zone or at the mouth of the stream that is or would be only a partial blockage at any time of year. Or there is a blockage in the draw-down zone that is or would be a blockage for some species at some times of the year.
NA	There is no blockage at the mouth of the stream or in the draw-down zone and there would not be a blockage at any time of year.
30	Blue or Red Listed Species Present

1) Complete blockage present during the fall, winter and spring.

2) A score of 30 pts for Habitat Capability and a score of 30 for blockage together in Matrix 2 results in an overall Matrix Score of 60 or High Priority rating for Mitigation.

Step Three

Matrix 3:
Habitat Capability Matrix.

Flow	**0 pts**	**N/A**	**20 pts**	**40 pts**	**Total**
Flow	No Flow	-	Intermittent	Perennial √	40
Survey timing should be scheduled to detect low flow in late summer. If stream is suspected or known to be intermittent and total habitat length is low to moderate (Step 1) then consider terminating assessment unless data indicates presence of vulnerable species.					
Gradient	**0 pts**	**0 pts**	**10 pts**	**20 pts**	**Total**
Gradient	>41	25-40	16-24	0-15 √	20
Cover	**0 pts**	**5 pts**	**10 pts**	**20 pts**	**Total**
LWD, U/C Bank and/or Boulder Cover	None	Trace	Subdominant	Dominant √	20
Vegetation Cover	None	Trace √	Subdominant or Dominant	-	5
SWD Cover	None	Trace	Subdominant or Dominant √	-	10
Spawning	**0 pts**	**10 pts**	**20 pts**	**40 pts**	**Total**
Spawning Habitat Quality	None	Poor	Moderate	Good-Excellent √	40
Species	**Blue or Red Listed Species Present**				**Default High Priority**
Matrix Score	Add matrix rows for total score				135

Matrix Score	Priority Rating	
≥60	High	√
40-50	Moderate	
≤30	Low	
Blue/Red Listed Species	High	

1) Culvert crossing approximately 150 m from stream mouth is a barrier. Re-calculate Matrix 1. New Priority rating is Moderate.

2) No fish sampling conducted.

3) Data used in Matrix 3 comes from Site Cards filled out during the field assessment. The gradient was 4.0 (20 pts), LWD was the dominant cover item (20 pts), there was only trace amounts of vegetative cover (5 pts), SWD was a subdominant cover (10 pts), and overall spawning habitat was excellent (40 pts). Overall matrix score is 135 pts or High Habitat Quality.

Step Four: Mitigation

Matrix 4:
Mitigation Prioritization Matrix.

	Blue or Red Listed Species 60	Habitat Capability ≥60	Habitat Capability 40-50	Habitat Capability ≤30
Barrier Rank 30	High	High √	High	Low
Barrier Rank 20	High	High	Moderate	Low
Barrier Rank 10	High	Moderate	Low	Low
Barrier Rank 0	N/A	N/A	N/A	N/A

After the debris is removed, a prevention option would be to build an artificial channel, because the embayment is fairly shallow. However, the substrate in the embayment is fine sand, and there is direct wave action at the end of the embayment, which could dislodge the channel. This option also may not be suitable for some species. Fish sampling should be done to determine what species are present, and ground testing should be done to determine the depth of the sand.

Reservoir Tributary Fish Access Assessment Protocol

Field Guide

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Field Guide

Matrix 1:
Pre-field assessment and prioritization matrix.

	5 pts	10 pts	20 pts	Total
Length of Available Habitat (m)	< 200 m	200-1000 m	> 1000 m	
Species Present (can have more than one category)	N/A	N/A	Blue/Red Listed species	Default High Priority
Matrix Score				

Matrix Score:	Priority for Field Assessment
20	High
10	Moderate
5	Low
Blue/Red Listed Species	High

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Matrix 2:
Barrier ranking matrix.

Score	Barrier Description
30	There is complete blockage at the mouth of the stream or in the draw-down zone that is or would be a complete blockage at all water levels or during all spawning periods.
20	There is a complete blockage in the draw-down zone or at the mouth of the stream that is or would be a complete blockage during some spawning periods only.
10	There is a partial blockage in the draw-down zone or at the mouth of the stream that is or would be only a partial blockage at any time of year. Or there is a blockage in the draw-down zone that is or would be a blockage for some species at some times of the year.
NA	There is no blockage at the mouth of the stream or in the draw-down zone and there would not be a blockage at any time of year.
30	Blue or Red Listed Species Present

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Matrix 3:
Habitat capability matrix.

Flow	**0 pts**	**N/A**	**20 pts**	**40 pts**	**Total**
Flow	No Flow	-	Intermittent	Perennial	
Survey timing should be scheduled to detect low flow in late summer. If stream is suspected or known to be intermittent and total habitat length is low to moderate (Step 1) then consider terminating assessment unless data indicates presence of vulnerable species.					
Gradient	**0 pts**	**0 pts**	**10 pts**	**20 pts**	**Total**
Gradient	>41	25-40	16-24	0-15	
Cover	**0 pts**	**5 pts**	**10 pts**	**20 pts**	**Total**
LWD, U/C Bank and/or Boulder Cover	None	Trace	Subdominant	Dominant	
Vegetation Cover	None	Trace	Subdominant or Dominant	-	
SWD Cover	None	Trace	Subdominant or Dominant	-	
Spawning	**0 pts**	**10 pts**	**20 pts**	**40 pts**	**Total**
Spawning Habitat Quality	None	Poor	Moderate	Good-Excellent	
Species	**Blue or Red Listed Species Present**				**Default High Priority**
Matrix Score	Add matrix rows for total score				

Matrix Score	Priority Rating
≥60	High
40-50	Moderate
≤30	Low
Blue/Red Listed Species	High

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Matrix 4:
Mitigation prioritization matrix.

	Blue or Red Listed Species 60	Habitat Capability ≥60	Habitat Capability 40-50	Habitat Capability ≤30
Barrier Score 30	High	High	High	Low
Barrier Score 20	High	High	Moderate	Low
Barrier Score 10	High	Moderate	Low	Low
Barrier Score 0	N/A	N/A	N/A	N/A

Reservoir Tributary Fish Access Assessment Protocol

Field Guide

Table 1:
Mitigation Options

Timing	Method	Disposal	Machinery
Full Pool	pile above water line	burn	chainsaw
	pile above water line	leave on site	chainsaw
	remove debris with net/hooks	pile above HWM	tug/barge excavator with thumb
	debris through chipper	load on barge	tug/barge excavator with thumb, chipper
Low Pool	pile by hand above HWM	burn	chainsaw
	pile by hand above water line	burn	chainsaw
	use machine pile within draw-down zone	burn	excvator with thumb, may require tug and barge to transport in inaccessible areas
	debris through chipper	disperse on site above HWM	tug/barge excavator with thumb, chipper
	debris through chipper	load on barge	tug/barge excavator with thumb, chipper

Reservoir Tributary Fish Access Assessment Protocol

Field Guide

Table 2:
List of possible prevention techniques for stopping blockages from forming.

Method	Materials	Site Considerations	Other Considerations	Estimated Cost
Log Boom	large logs, cable anchors across mouth	• will not prevent small debris or any debris in windy/high wave • could block entry to stream mouth - pose a safety hazard for boaters	only suitable for streams with long well protected bays	
Steel Piles	steel piles 10-20 m long across mouth	• appropriate substrate required, will not prevent small debris, could block entry to stream mouth - pose a safety hazard for boaters	must withstand storms and pressure from large debris accumulation	
Wood Piles	wood piles 10-20 m long across mouth	• appropriate substrate required, will not prevent small debris, could block entry to stream mouth - pose a safety hazard for boaters	must withstand storms and pressure from large debris accumulation	
Culvert/ Artificial Channel	metal or wood culvert	Debris removal not necessary as channel will be accessible underneath debris	will require engineered substrate, must extend past debris jam, fish access may be impeded at full pool	
Log Pile Lined Channel	wood piles along channel	Suitable substrate for piles side by side for length of channel	require cross members for strength, accumulation within the channel	
Given that there will be a continued source of debris into the foreseeable future, debris tracking and targeted clean-up may be a more reasonable alternative. There are water based logging and clean-up operations in place on various reservoirs across British Columbia. These can provide examples of the equipment requirements and cost analysis.				

Reservoir Tributary Fish Access Assessment Tracking Form

WSC	UTM			Barrier Type	Barrier Class	Flow	Gradient	Cover			Spawning Quality	Capability Class	Blue/Red Species	Length Class	Overall Priority
	Zone	East	North					LWD	SWD	VEG					

Reservoir Tributary Fish Access Field Assessment Data Form Side A

Tributary name:_____ Site #:_____, WSC:_____

Date: _____ Time:_____ Season:_____

Reservoir Level: ☐ High ☐ Moderate ☐ Low Comments_____

Stream Priority: ☐ High ☐ Moderate ☐ Low

Lat/Long: Zone _____, Lat:_____, Long:_____

or UTM: Zone _____, Nor:_____, East:_____

Reservoir Water Elevation: _____

Length of Draw-down Zone (m): _____,

Depth of stream channel at mouth (m): _____ Substrate: _____

Type of Barrier: Debris ☐ Dewatered ☐ Gradient ☐

Velocity ☐ No Distinct Channel ☐ Other ☐

Barrier :					
	Summer	Complete ☐	Partial ☐	None ☐	Unknown ☐
	Fall	Complete ☐	Partial ☐	None ☐	Unknown ☐
	Winter	Complete ☐	Partial ☐	None ☐	Unknown ☐
	Spring	Complete ☐	Partial ☐	None ☐	Unknown ☐

Longitudinal Section of Draw-down Zone:

Reservoir Tributary Fish Access Field Assessment Data Form Side B

Tributary name:_____ Site #:_____, WSC:_____

Debris Jam:

Debris jam length (m): _____, Debris jam width (m): _____, Debris jam depth (m):_____,

Estimated # of debris pieces: _____

Size of Average Debris piece: _____, Debris Compaction: ☐ High ☐ Moderate ☐ Low

Action of Debris:
☐ Floating ☐ Embedded in channel/ground ☐ Laying/suspended on channel/ground.

Does debris provide habitat for fish? ☐ Yes ☐ No

Dewatered Barrier: ☐

Length of Dewatered Portion (m): _____, Flow U/S: _____, Flow D/S: _____

Substrate along dewatered section: _____, Gradient(%): _____

Gradient Barrier: ☐

Upstream Elevation (m): _____, Downstream Elevation (m): _____

Substrate: _____,

Velocity Barrier: ☐

Length (m): _____, Water Velocity (m/s): _____, Gradient (%): _____

Substrate: _____, Turbulence (m): _____

No Channel Barrier: ☐

Length (m): _____, Width of Seepage (m): _____

Substrate: _____, Gradient (%): _____

Other Barrier Type: ☐

_____

_____

Roll # ____ Photo # ____ Description: _____

Roll # ____ Photo # ____ Description: _____

Roll # ____ Photo # ____ Description: _____

Roll # ____ Photo # ____ Description: _____

Roll # ____ Photo # ____ Description: _____

*Comments:*_____

_____